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Dwarf Mistletoes of Ponderosa Pine

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The dwarf mistletoes (*Arceuthobium* spp.) are important parasites found throughout most of the range of ponderosa pine (*Pinus ponderosa*).

Ponderosa pine is parasitized by two widespread species. Southwestern dwarf mistletoe (*A. vaginatum* subsp. *cryptopodum*) occurs on the Rocky Mountain variety of ponderosa pine (*Pinus ponderosa* var. *scopulorum*) from Arizona and New Mexico into central Utah and northern Colorado. Western dwarf mistletoe (*A. campylopodum*) affects the Pacific coast variety of ponderosa pine (*P. ponderosa* var. *ponderosa*) from southern California to northern Washington and western Idaho (Figure 1).

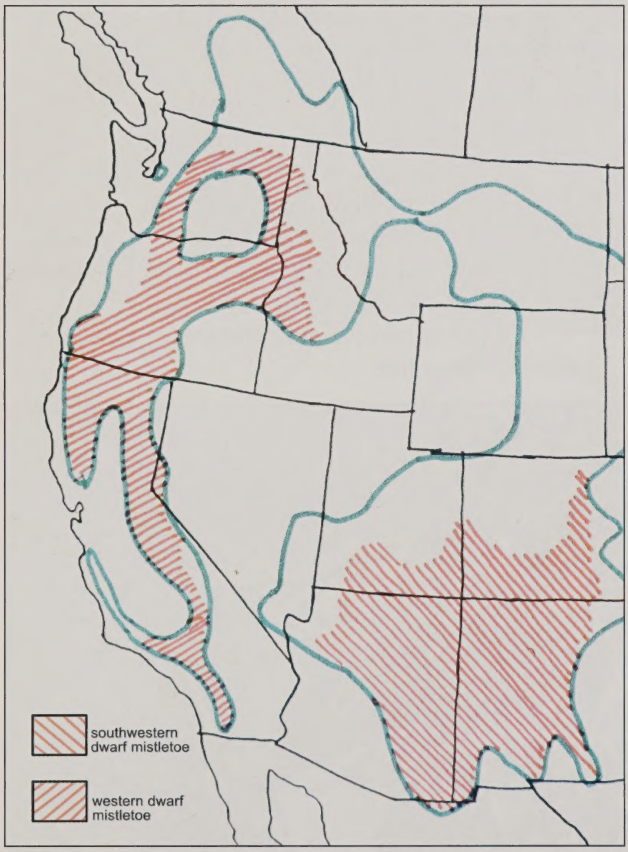

Figure 1. Distribution of southwestern and western dwarf mistletoes (shaded areas) and ponderosa pine (thick blue line).

Although both dwarf mistletoes occur primarily on ponderosa pine, they also commonly infect some related pines (Table 1).

Southwestern dwarf mistletoe is equally damaging to Arizona pine (*Pinus arizonica*) and Apache pine (*Pinus engelmannii*) in the

[1] This Insect and Disease Leaflet combines Leaflet #19 "Dwarf mistletoes of Ponderosa Pine in the Southwest" and #40, "Western dwarf mistletoe on Ponderosa Pine." [2] Jerome Beatty is Deputy Director, USDA Forest Service, Forest Health Protection, Washington, DC; [3] Robert Mathiasen is Associate Professor, School of Forestry, Northern Arizona University, Flagstaff, AZ.

Southwest. Similarly, western dwarf mistletoe frequently infects Jeffrey pine (*Pinus jeffreyi*) and Coulter pine (*Pinus coulteri*) in California.

Both mistletoes will also attack some introduced pines; those hosts are listed in Table 1.

Dwarf mistletoes do not have large leaves; instead their leaves are small squamate scales found at the nodes of shoots. The average height of aerial shoots for these mistletoes is about 4 to 6 inches (10-15 cm).

Aerial shoots arise from a network

Table 1. Hosts of southwestern and western dwarf mistletoe.

Susceptibility Class	Southwestern Dwarf Mistletoe (*Arceuthobium vaginatum*)	Western Dwarf Mistletoe (*Arceuthobium campylopodum*)
Principal hosts	Rocky Mountain ponderosa pine Arizona pine Apache pine	Pacific coast ponderosa pine Jeffrey pine
Secondary hosts[1]		Coulter pine Knobcone pine
Occasional hosts[2]	Rocky Mountain bristlecone pine Rocky Mountain lodgepole pine	Grey pine Rocky Mountain lodgepole pine Sierra lodgepole pine
Rare hosts[3]	Limber pine Southwestern white pine	Sugar pine

[1]*Trees frequently attacked when they are associated with infected principal hosts*
[2]*Trees occasionally attacked when associated with infected principal host*
[3]*Trees rarely attacked, even when associated with infected principal hosts*

Life History

The external (aerial) shoots of western dwarf mistletoe are olive green to brown or yellow-brown (Figure 2). The aerial shoots of southwestern dwarf mistletoe are orange to reddish-brown to almost black (Figure 3).

of root-like absorbing strands imbedded in host tissues. This network, called the endophytic system, consists of cortical strands growing within the bark and sinkers within the wood. The endophytic system obtains nutrients and water from the host tree.

Figure 2. Female shoots of western dwarf mistletoe.

Table 2. Flowering and seed dispersal periods of the two ponderosa pine dwarf mistletoes.

Characteristic	Southwestern Dwarf Mistletoe *(Arceuthobium vaginatum)*	Western Dwarf Mistletoe *(Arceuthobium campylopodum)*
Flowering period	May - June	August - October
Seed dispersal period	July - August	September - November
Germination	Seeds germinate immediately after seed dispersal	Seeds overwinter and germinate fhe following April - May

The endophytic system usually lives as long as adjacent host tissues are alive. The mistletoe is dependent upon its host trees for water and nutrients, and most of its carbohydrates. Although the aerial shoots contain chlorophyll that allows them to produce small amounts of carbohydrates, the major function of aerial shoots is reproduction.

in length. Seed dispersal is one of the most interesting characteristics of dwarf mistletoes. Seeds are discharged explosively from ripe fruits in late summer for southwestern dwarf mistletoe and early fall for western dwarf mistletoe (Table 2).

Seeds may travel 10-13 m, but most land within 3-5 m of the dis-

Figure 3. Female shoots of southwestern dwarf mistletoe.

Male and female flowers are small and produced on separate plants. Southwestern dwarf mistletoe flowers in the spring and western dwarf mistletoe in the fall (Table 2). Insects and wind pollinate female flowers.

Fruits complete their development 12 to15 months after pollination. The mature fruits contain one seed averaging about 0.2 inches (3 mm)

seminating shoot. A sticky seed coating called viscin enables seeds to stick to most objects they strike. Foliage is the most common receiving surface. Viscin acts as a lubricant when moistened by rain. Seeds slide down and either fall off needles or become lodged on bark near the base of needles. Seeds are fastened in place when the viscin dries.

Seeds are often destroyed by insects and fungi or dislodged by rain or snow, so only a small proportion of the seeds dispersed actually survive and cause new infections.

Seeds of southwestern dwarf mistletoe germinate immediately after dispersal, while those of western dwarf mistletoe over-winter and germinate in early spring.

A root-like structure called a radicle emerges from the seed and grows along the bark surface until an obstruction, usually a needle base, is encountered. The radicle then forms a mound of tissue called a holdfast. The holdfast develops an infection peg, which penetrates into host tissue. The mistletoe's endophytic system then develops in the outer bark and wood of the infected part of the host.

Infection occurs most readily in twigs less than five years old because their bark is more easily penetrated than older twigs.

Aerial shoots typically appear 2 to 3 years after initial infection. Infections that have not yet produced aerial shoots are called latent infections. The typical length of time needed for female plants to complete their life cycle from initial establishment to dissemination of the first seed crop is 4 to 5 years for both of these dwarf mistletoes.

Symptoms and Signs of Infection

The first symptom of dwarf mistletoe infection is the appearance of slight swellings at infection sites. Swellings become visible 1 to 2 years after infection occurs. Aerial portions of male and female plants appear after a year or two after the swellings are visible. When shoots fall off of infected branches they leave behind small cup-like structures embedded in the bark. These are called basal cups.

As time passes and the endophytic system of the parasite becomes more extensive, the branching habit of the host may become distorted and witches' brooms are formed. Witches' brooms are variously shaped masses of abnormal branch and twig growth. Broomed branches usually outlive their uninfected neighbors by many years. They divert food from uninfected parts of the tree and thus are instrumental in reducing vigor and causing premature death of severely infected trees.

Long-lived witches' brooms also result in excessively large knots; it is not uncommon for the base of broomed branches on otherwise clear trunks to become over 10 inches (25 cm) in diameter. Resinous cankers may result from mistletoe infection of the main stem, especially on smaller trees.

Severely infested pine stands typically have many trees with stunted growth, witches' brooms, dying or dead tops and branches, and dead trees. Dieback occurs as nutrients and water needed by growing tree tops are diverted to infections that are usually concentrated in the lower or mid crowns.

Foliage near infections becomes sparse and off-color and gradually the upper branches die. Eventually height growth slows, and such trees may subsequently be attacked and killed by bark beetles. These stands eventually contain numerous dying and dead trees, usually bearing remnants of witches' brooms.

Spread and Intensification

Several interrelated factors influence tree-to-tree spread of ponderosa pine dwarf mistletoes. These include tree size, tree spacing, stand structure, species composition of stands, and infection position.

In single-storied stands, spread is estimated to be 2-3 feet (0.6-1.0 m) per year. Spread in multi-storied stands is more rapid because understory trees are exposed to dwarf mistletoe seeds from infected overstory trees. Presence of non-host tree species can slow the spread of ponderosa pine dwarf mistletoe. Spread rates in very dense stands are less than in more open stands because dwarf mistletoe seed production is usually reduced due to limited light and lower host vigor, and many seeds are trapped before they travel far. Dwarf mistletoe seeds from plants high in tree crowns tend to travel farther than those in lower portions of crowns.

Nearly all spread is local and results from explosive discharge of seeds. Wind exerts a minor influence on distance and direction of seed travel. Birds and other animals are responsible for some long-distance spread when seeds stick to them and later are rubbed off onto susceptible trees.

The 6-class dwarf mistletoe rating (DMR) system is useful for quantifying intensity of infection in trees and stands. For this system, the live crown of the tree is visually divided into thirds and each third rated as: 0 = no visible infection, 1 = light infection (less than half of the branches in the crown third have dwarf mistletoe infections), or 2 = heavy infection (more than half of the branches in the crown third have infections). The three ratings are then added to obtain a tree rating ranging from 0 (healthy trees) to 6 (severely infected trees). The tree ratings of all live trees in a stand or plot (including uninfected ones) are then summed and the total divided by the number of live trees to obtain an average rating for the stand. Average dwarf mistletoe ratings for a stand can then be used to help determine what management options can be considered for the infested area.

Dwarf mistletoe ratings can also be used to help decide which trees should be removed or retained if a decision is made to conduct harvesting or thinning treatments in the infested area.

As a rough rule-of-thumb, intensification of pine dwarf mistletoe averages about one DMR class per decade for individual trees, but varies with tree size, stand position, and overstory infection. Infection intensifies most rapidly in sapling or pole-size trees under severely infected larger trees.

Impacts

Infection of ponderosa pine by dwarf mistletoe causes increased mortality, reduced growth rates and loss of vigor, lowered timber quality, reduced cone and seed production, and increased susceptibility to other damaging agents. These damaging effects result from the dwarf mistletoe plants taking food and water from the host, thus reducing the amount available for the tree's normal growth, protective, and reproductive processes.

The effect of dwarf mistletoe on growth increases with severity of infection and is especially acute in severely infected trees (DMR = 5 or 6). Tree volume growth can be

reduced by as much as 50% in severely infected trees. Severely infected trees (DMR = 6) usually live less than 10 years in the Southwest.

Quality of lumber in infected trees can be reduced because dwarf mistletoe sometimes infects the boles of trees. Knots often are associated with branches supporting witches' brooms. Severely infected trees typically produce few cones, and those that are produced are smaller than normal and contain fewer seeds.

Dwarf mistletoes can adversely affect other forest values. Witches' brooms and dead branches can increase the hazard potential in recreation sites because they may cause trees and branches to break and fall. Dead and dying trees detract from visual quality. Potential for wildfires is increased because of resin soaked live branches, dead branches, increased tree mortality, and the accumulation of dead, resinous branches around the bases of infected trees.

However, dwarf mistletoe infection can also have beneficial effects. Flowers, shoots, and fruits are food for insects, birds, and mammals. Mortality caused by dwarf mistletoe, either directly or by predisposing trees to other agents, provides snags as habitat for cavity-nesting birds and, eventually, coarse-woody debris on the forest floor. Dwarf mistletoe brooms create additional structure and various species of wildlife use the witches' brooms as nesting sites.

Management

In forest ecosystems, dwarf mistletoes have value as individual, biological species and act as disturbance agents, influencing both the structure and function of forest communities. Management of ponderosa pine dwarf mistletoes must recognize their value as functional components of forest ecosystems. In areas where timber production or developed recreation is the primary goal, direct control of dwarf mistletoe may be warranted. In other areas, where wildlife or esthetic values are more important, maintaining or even increasing dwarf mistletoe populations may be appropriate.

Cultural Controls

The only practical control of ponderosa pine dwarf mistletoes over large forested areas is through cultural treatments. No chemical or biological controls are available for treating stands.

Profitable production of timber in many local areas often depends on management of dwarf mistletoe. Because the parasite can cause large reductions in yield, management should be considered in all timber-producing stands where dwarf mistletoes occur.

Successful timber volume production is almost impossible in multistoried, infested stands. Silvicultural treatments designed to achieve single-storied stands offer the best prospects of preventing unacceptable losses to dwarf mistletoes.

The most effective method for eliminating dwarf mistletoes from timber-producing forests is complete harvest of infested stands by clearcutting. After usable trees are harvested, all remaining infected trees should be killed.

To minimize invasion of young pine stands by dwarf mistletoe from infected border trees, the ratio of perimeter to area of clearcuts should

be as low as possible. That is, cut openings should be roughly circular and not long, narrow strips.

Advantage should be taken of any potential barriers to dwarf mistletoe spread, such as roads, ridgetops, natural openings, and changes in timber types when laying out the boundary of a clearcut.

When clearcutting of dwarf mistletoe-infested stands is not appropriate, shelterwood and seed tree harvests can be good alternative even-age management methods. Trees selected to provide shelter or seeds should be uninfected or only lightly infected (DMR < 3).

Moderately and severely infected trees, in addition to being a source of dwarf mistletoe seeds, produce poorer crops of tree seeds. Infected shelterwood or seed trees should be removed as soon as susceptible reproduction becomes established. As a general rule for most dwarf mistletoes it is desirable to remove the infected overstory before the young stand is 3 feet (1 m) tall or 10 years old, whichever occurs first.

In mixed-species stands that contain pines infected by dwarf mistletoe, silvicultural treatments should favor other tree species. Non-hosts left between infected and non-infected pines prevent or slow spread and intensification of the parasite.

Thinning or sanitation by removal of infected trees can be an effective treatment in lightly infested stands. Lightly infested is defined as those stands in which there are acceptable numbers of desirable dwarf mistletoe-free or lightly infected (DMR <3) trees. Trees with one-half or more of their crowns infected by dwarf mistletoe (DMR >3) may decline rapidly about 10 years after they are exposed to full sunlight by thinning.

Because of their rapid decline, moderately infected trees should not be left when stands are being sanitized unless they can be expected to reach merchantable size within 15 years.

Thinning priorities should be based on both dwarf mistletoe severity and live crown ratios. First priority for removal should be all trees with a live crown ratio < 40% or trees with live crown ratios < 60% with a DMR of 5 or 6. Last trees to be removed should be those with a live crown ratio > 80% and a DMR < 3.

In stands where management of hiding and thermal cover for wildlife is a primary consideration, infected trees with large witches' broom should be treated by girdling rather than felling.

Reexamination of stands 5 years after sanitation is desirable to determine if additional sanitation is needed. Moderately and severely infested stands should not be sanitized because many trees with latent infections will be missed, and once these trees are released from competition, the number of dwarf mistletoe plants will increase rapidly within their crowns. Such stands should either be clearcut and regenerated or left unthinned to avoid their rapid decline.

Latent dwarf mistletoe infections in trees in densely stocked stands and in shaded reproduction are very difficult to detect. It should be assumed that understory trees more than 3 feet (1 m) tall that have been overtopped by infected trees for at least 10 years are probably infected.

Recreation Management

In recreation areas, sanitation treatments that favor non-susceptible hosts or remove infected overstory trees are appropriate. Pruning, in conjunction with removal of severely infected trees, can prolong the life of individual trees.

For high value trees, removal of live witches' brooms that exert a large drain on infected trees can improve their vigor and prolong their life. Trees may have to be repruned occasionally to remove developing witches' brooms. Candidates for pruning are trees with infections only in the lower half of their crown.

In addition to prolonging tree life, pruning can reduce the danger of trees or branches breaking and prevent damage and subsequent liability from falling branches. Trees with bole infections may contain decayed wood and therefore may have a higher potential to fail.

Assistance

Resource managers can get more information about the identification and management of dwarf mistletoes of ponderosa pine by contacting a County Cooperative Extension agent, their local state forestry office, or their regional USDA Forest Service, Forest Health Protection office.

References

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Pesticides used improperly can be injurious to humans, animals, and plants. Follow directions and read all precautions on the labels. Consult your local forest pathologist, county agricultural agent, or State extension agent about restrictions and registered uses of particular pesticides.

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